ASHRAE: Reducing the Impact of Refrigerants on the Environment

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Abstract

Conversations about sustainable buildings typically focus on the need for water and energy efficiency and green building materials. Also very important in the move toward sustainability is the need to reduce the impact of refrigerants on the environment. ASHRAE President 2012-13 Tom Watson emphasizes the Society's work in refrigerants and what is being done to reduce their impact on the environment.

Conversations about sustainable buildings typically focus on the need for water and energy efficiency, indoor air quality, thermal comfort, lighting/daylighting, acoustics and green building materials. Equally important in the move toward sustainability is the need to reduce the impact of refrigerants on the environment.

As we all know very well, emitted chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants have been directly linked to the destruction of stratospheric ozone, which in the upper atmosphere shields us from harmful ultraviolet B radiation (a component of sunlight). They, along with hydrofluorocarbon (HFC) refrigerants also act as greenhouse gases with potential consequences for global warming and other climate change effects. The HCFC and HFC refrigerants that replaced CFC refrigerants such as R-12 and R-114 have reduced global warming potentials by nearly an order of magnitude lower. However, there is a need to utilize even lower direct global warming potential refrigerants to meet our environmental goals. This will require worldwide cooperation by governments, manufacturers of refrigerants and equipment that use refrigerants, installers and service technicians and owners and operators of facilities using refrigerants. It is important that ASHRAE and the ASHRAE Associate Society Alliance members such as ISHRAE provide sound technical information to base the difficult decisions we must make.

About the Author

Tom Watson, is chief engineer, Daikin McQuay, Staunton, Virginia, USA. He oversees new product development for centrifugal compressor technology and is primarily involved in technical areas related to refrigerant applications, aerodynamics, bearing design and motor applications. He holds five patents related to refrigerant, gas and chiller compressors.

His ASHRAE presidential theme is Broadening ASHRAE's Horizons, which emphasizes the role of ASHRAE members as leaders in the application of sustainable design and practices in communities worldwide.

As industries transition away from ozone-depleting and high global-warming potential substances, we must turn to a more holistic analysis in the selection and regulation of refrigerants and the systems utilizing these chemicals. Besides high energy efficiency and performance, we must consider community safety, personal safety, economic and social impacts and minimization of other environmental impacts that may result from prioritizing lower global warming potential (GWP).

A few important issues related to refrigerants and their impact on the environment:

- Choosing a refrigerant will require much more knowledge
- Environmental concerns due to ozone depleting potential, global warming potential, energy efficiency that are incorporated into life cycle climate performance
- Safety standards must be updated to allow the use of flammable/mildly flammable working fluids that have low global warming potential.

Certainly, we have made much progress in our use of refrigerants to heat and cool our indoor environments. At a recent refrigerants conference hosted by ASHRAE and the National Institute of Standards and Technology, keynote speaker James M. Calm shared his thoughts on refrigerant transitions.

Calm categorized the transition of refrigerants into four generations. The first generation spanned from the 1830s-1930s and could be characterized by "using whatever worked." The second generation (1931-1990s) focused on safety and durability, which included introduction of CFCs and HCFCs, as well as continued use of ammonia and to a lesser extent hydrocarbons. More recently was the third generation (1990-2010s), when industry concern turned to ozone protection and began phaseout of CFCs and later HCFCs. We are now entering the fourth generation of refrigerants (2012 and beyond) with focus on global warming and low GWPs options. He emphasizes the need to address the several application requirements and looming environmental concerns, including new ones, together, as piecemeal approaches will not meet the eventual targets.

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My interest in refrigerants lies in considering how they relate to products. As I have traveled this year for both my ASHRAE service and my work, I have heard much conversation about the need for analysis considering all facets of buildings and systems. There is an increasing focus on using low GWP refrigerants in high-efficiency systems. Improving efficiency in air conditioners, heat pumps and refrigeration is, and will remain, critical as the energy used and resulting emissions have more significant impact on climate change than the refrigerants themselves. So it is critical that facility managers carefully address not only refrigerant selection and leak minimization, but also building or facility efficiency. When speaking of holistic approaches, the linkage between energy use and production with water use has to be considered. It is becoming widely known that a high percentage of fresh water use is tied to energy. Similarly, the global warming resulting from the use of air-conditioning and refrigeration is very much tied to the energy consumed as well as the refrigerant used.

There are several programs and initiatives underway focused on the technologies, methods and means needed to accommodate the imminent phase-down of high-GWP refrigerants.

Requirements in ANSI/ASHRAE Standard 34-2010, *Designation and Safety Classification of Refrigerants*, and ANSI/ASHRAE Standard 15-2010, *Safety Standard for Refrigeration Systems*, complement each other in that Standard 34 describes a structured way of naming refrigerants and assigns safety classifications based on toxicity and flammability data, while Standard 15 establishes procedures for design, construction and operation of equipment and systems when using those refrigerants.

Many of the new low-GWP refrigerants have been classified under Standard 34's new 2L safety classification. The 2L designation is for refrigerants that have "flame speed of less than 10 cm per second." The Standard 34 committee is near completion of an applications checklist to assist persons in assembling properly organized and complete applications. The checklist will not be included in the standard but will be available for download from the standard committee's website.

In addition, ASHRAE Standard 15 is currently undergoing revisions to address the 2L classification.

Another new project is development of a 'Guide for Sustainable Refrigerated Facilities and Refrigeration Systems,' by ASHRAE and the United Nations Environmental Programme.

This $460,000 project is being jointly funded by ASHRAE and the Multilateral Fund for the Implementation of the Montreal Protocol on Substances that Deplete the Ozone Layer, and is scheduled to be completed in early 2014.

The Guide will discuss retrofit options with clear principles for replacement of conversion of facility and equipment design and for refrigerated processing, storage and distribution (the cold chain) in both developed and developing countries. As global urbanization continues, refrigerated storage and transport from farm to store is critical. Food spoilage is a significant sustainability problem, particularly in the developing countries. Medicine storage and transportation is also critical and is impacted by this guide. The Guide should be of particular importance for facility mangers throughout the world.

The 'Guide for Sustainable Refrigerated Facilities and Refrigeration Facilities' will be important as Parties to the

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Montreal Protocol face upcoming compliance deadlines. For developing countries, that means a freeze in HCFC consumption and production by Jan. 1, 2013, followed by a 10 percent reduction in 2015 and a 97.5 percent reduction by 2030. Currently, HCFC-22 is the most commonly used refrigerant for many facilities and systems, particularly for small-medium sized conditioners, but this ozone-depleting gas is being phased out under the Montreal Protocol. The goal of the Guide is to support the selection of alternatives while maintaining or improving energy efficiency across the entire cold chain and thereby reducing the environmental impact. That, in turn, supports countries' compliance with this international treaty and improves global sustainability.

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Another program ASHRAE is creating a voluntary refrigerant management plan, with implementation initially planned for the United States. Proper cradle to grave management is necessary to minimize refrigerant releases and minimize their environmental impact. It also gives guidance for refrigerant selection to be used by the HVAC&R industry to meet the growing demand.

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To help save energy and protect the quality of food throughout the cold chain, ASHRAE is developing a 'Refrigeration Commissioning Guide.' Funded in part by the U.S. Department of Energy, the guide addresses commissioning of custom-designed low and medium temperature refrigeration systems with a focus on supermarket refrigeration systems in particular. Though commissioning has long been associated with commercial buildings and HVAC systems, owners and designers in the refrigeration industry are now also moving toward commissioning.

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Commissioning improves the performance and reliability of refrigeration systems and helps ensure that project requirements and owner's expectations are achieved. The Refrigeration Commissioning Guide provides simple, practical how-to guidance for commissioning of refrigeration systems in new construction commercial and industrial facilities, including expansions and renovation. In addition, many of the procedures and processes can also be used to recommission existing refrigeration systems. The guide is meant to be used by system owners, architects, design engineers, contractors, facility managers and refrigeration service companies, as well providers of commissioning services.

Thousands of refrigeration systems are installed every year in facilities ranging from convenience stores to large and sophisticated frozen food distribution centers. Figures from the Food Marketing Institute's 2011 Industry Overview indicate there are more than 36,000 supermarkets with a medium size of 46,000 square feet in the United States alone. Refrigeration systems consume large amounts of energy, are costly to maintain and have relatively high refrigerant leak rates – all factors that commissioning can improve.

Commissioning requirements for refrigeration systems are different from the commissioning required for HVAC systems. Typically, commercial and industrial refrigeration systems are custom-built with individually selected, rather than factory-assembled, packages. Each system is unique and performance is greatly affected by component interactions and control methods. Most refrigeration components (unlike HVAC equipment) are not provided or certified to a rating standard; moreover, the applied conditions may be significantly different than the commonly available rating standards. Sizing, design practice and equipment performance expectations are thus subject to significant approximate methods and experience factors. Refrigeration must perform (maintain temperatures) at all times, making conservative design factors a practical necessity, although the amount of the design factor is rarely verified in operation.

With the guide, ASHRAE aims to create a modular approach that is consistent with how refrigeration projects are commonly designed, contracted and implemented, and to improve and supplement, but not replace, existing design, construction and operational practices. Commissioning must be carefully considered and adopted so the existing responsibilities for design, supplier compliance and contract completion—which most companies have successfully refined to achieve on-time and on-budget projects—are not diminished.

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We also are working with the Federation of European Heating and Air Conditioning Associations (REHVA) and the Scandinavian Federation of Heating, Ventilation and Sanitary Engineering Associations (SCANVAC) on the development of a new 'Cold

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Climate Design Guide.' ASHRAE has formed a working group with input from REHVA and SCANVAC to publish a new design guide for cold climates, based on a request from our chapter in the province of Manitoba, Canada. Members there asked that we publish a guide to assist designers to optimally select systems and technologies which provide robust and maintainable HVAC&R systems in moderate to severe winter climates. The guide is expected to be published next year and will address zero carbon energy usage and technical risks associated with newly emerging renewable technologies and other areas of development.

This year, ASHRAE is emphasizing that engineers and those who install and maintain new technologies are the leaders in sustainable practices in our communities. I am concentrating on how the three focal points of technology, applications and people combine to develop stronger, more sustainable communities.

Our technology needs to consider many issues: climate, culture, how people think about air conditioning, how dependent a society is on refrigeration and economics. In my home town, and in every one of your communities, there are economic issues. We need to consider our resources, the technical education of the labor force and the infrastructure available to us. These are the challenges we face in balancing what our technology offers with what people want and what people can afford. In many cases, we have not yet achieved the balance needed to meet the needs of all of the communities throughout the world that we serve.

“So what can we, as an industry, do? We need to focus on our greatest impact. We need to match the technology to the need. We need affordable regional technologies, and we need to benefit our communities and ourselves.”

However, as great as all of this technology is, we need to keep the users in mind. We need to keep it simple. Do we really need those latest technologies in all cases? Do we need super-sophisticated solutions? Do we need complicated buildings and systems? We need to focus on impact, making sure the advanced technology is used throughout the life of the building, not just installed as a showpiece to win an award, then not used. We need to have buildings that remain viable for years to come. We need to use innovation that works. An important issue for our industry is providing simple, affordable solutions. We need to use global expertise to meet local needs.

Our control systems are too complicated. I remember 30 years ago when I became involved with a wonderful project. I was so proud of it – a triple cascade system that took water from 4°C to 90°C. It had three different machines cascaded with different refrigerants. Technically wonderful, but the controls were so complicated that only two people in the world—I happened to be one of them—could start the machines. It was great technology, but it was too difficult to understand and to operate. Those are exactly the types of solutions that we do not need. The operating staff must be considered at the very beginning stages of the design.

We are not alone in this endeavor. Venues such as ASHRAE conferences and industry conferences such as ISHRAE's ACREX afford us the opportunity to share what our industry is doing in each corner of the globe so the most effective solutions can be reached.

The ACREX show provides a vehicle by which we can bring together technology, applications and people to meet those needs. The event is very important to ASHRAE because it creates an audience with which our Society can share its technical guidance. ASHRAE has a large role to play in our global environment, and our members in India are a vital part of that role. With seven chapters and some 1,000 members, India is in our top 10 countries based on number of members. This tells me that our members and the built environment industry here in India are eager to be leaders in the application of sustainable design and practices in our communities worldwide.

Let me share some information about a new program this year: we are reaching out to other engineering and technical students with a new design competition. This new design challenge is aimed at students who are not traditionally involved with ASHRAE and also at traditional schools that have existing engineering programs. The challenge focuses on both refrigeration and renewable energy, and will require teams of engineering students to design a portable 30 litre volume refrigeration unit powered entirely by renewable energy.

This device could be used to transport small essential cargo (perishable foods, pharmaceuticals, organs, sensitive equipment, etc.). The temperature inside the box must be maintained at -4°C continuously without an external power supply, in an ambient environment of 38°C. This device must be easily made anywhere in the world, especially in the country where it will be used.

Specifically with the Applied Engineering Challenge, we're looking for technologies that can be built very inexpensively and effectively and provide an immediate benefit to people around the world. This program will continue into the future with similar types of projects based on the various aspects of ASHRAE technologies.

So what can we, as an industry, do? We need to focus on our greatest impact. We need to match the technology to the need. We need affordable regional technologies, and we need to benefit our communities and ourselves.

The contributions of everyone in the industry today – engineers, contractors, manufacturers, designers, suppliers, association representatives, governmental officials, researchers – are needed to create not just new technologies but technologies that are applied correctly and benefit people. ❖